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The fatty acid composition of umbilical cord serum, infant serum and maternal serum and its relation to the diet

By

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With 3 figures and 4 tables

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Introduction

In the search for the aetiology of multiple sclerosis, the role of the lipid composition of the diet (3, 20, 23) has created interest in the composition and effect of the diet during the neonatal period, during which time the most rapid membrane formation occurs (4). The interest has been focused on the dietary content of polyunsaturated fatty acids (PUFA), as these acids are known to be present in normal human central nervous system (17). Investigations of the effect of diets containing different types of fat have been carried out in laboratory animals (1, 8, 10, 24), and in infants (7, 9, 16, 18, 25).

Our data show the fatty acid composition of serum from infants fed on commercial milk products containing different amounts of PUFA. Further, we have tried to establish if a relationship exists between the fatty acid composition of breastmilk and maternal serum and/or between that of breastmilk and infant serum. Finally, the fatty acids of maternal and cord serum are compared to those of mother and child some days post-partum.

Materials and Methods

Samples of breastmilk were obtained from the neonatal and obstetric wards at Rigshospitalet, Copenhagen. A group of samples taken 4–7 days post-partum were compared to a group of samples taken later in the lactation period. The two commercial milk products used in the study were S[1]) and E[2]).

Maternal blood samples were obtained by venepuncture; infant sera were separated from capillary blood from the heel. All samples were taken 1–1$^1/_2$ hours after feeding.

The lipids were extracted from 0.2–0.5 ml of serum and 0.5 ml of milk or milk substitute with $CHCl_3$–CH_3OH(2:1) and washed with the theoretical upper phase according to the procedure of FOLCH (6). Methylesters of the fatty acids were produced with HCl in superdry CH_3OH according to standard methods (2). The methylesters were analyzed by gas chromatography in a Perkin Elmer GasChromatograph model F-7 or F-11 using 2 m

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[1]) S: i. e. Semper. (batsch, 1967)

Composition of 100 g dry product (475 kcal): protein 17%, fat 18.5%, (dextrose, maltose, sucrose) 17%, lactose 40%; vitamin A 900 IU, Vitamin D 370 IU, vitamin B_1 0.37 mg, vitamin B_2 0.67 mg, vitamin B_6 0.22 mg, niacin 4.8 mg, vitamin C 40.7 mg, vitamin E 3,7 mg, (Ca, P, Fe) 9.2 mg. Linoleic acid not less than 4% of total calories.

[2]) E: i. e. Eledon, Nestle.

Composition of 100 g dry product (416 kcal): protein 18.4%, fat 9.5%, lactose 23.5%, (dextrose, maltose, sucrose) 38%, minerals 3.8%, lactic acid 2.8%.

columns packed with 15% diethyleneglycolsuccinate on Chromosorb W (Applied Science Labs., Pennsylvania); N_2 was used as the carrier gas. The isolated esters were compared with reference mixtures (Hormel Institute, Minnesota, or Analytical Standards, Gothenburg), and with the retention volumes, as reported by JAMES (12), or by log-plotting. The time used for the individual analysis corresponded to the retention time of C 22:1. Analytical error of the gas chromatographic analysis was 5% for palmitic acid, but up to 20% for arachidonic acid when different columns of different ages were compared. All results are given as percentage of the total fatty acids estimated.

Statistical evaluation: Identity or difference between groups of data was evaluated on the basis of "Student's t" distribution (21) considering groups significantly different for $t > t_{0.99}$.

Results

In Table 1 the fatty acid composition of breastmilk taken A) during the first days of established lactation (4–7 days postpartum) and B) later in the lactation period is shown. The two groups are identical, and it was further found that milk from the same person had the same fatty acid composition at different times during the lactation period. When the two artificial milk products were examined, we found that S had a much higher proportion of essential fatty acids than breastmilk, whereas E showed a linoleic acid percentage which corresponded to the lower values found for breastmilk.

Table 1. Fatty acid composition of breast milk compared to two commercial milk products and cow's milk. (% of total fatty acids)

	Breast milk A N = 15 $\bar{x}$ s	Breast milk B N = 10 $\bar{x}$ s	S N = 5 range	E N = 5 range	Cow's milk N = 3 range
C 12:0	4.2 ± 1.2	4.7 ± 2.5	9.3–13.7	1.1– 2.8	1.9– 2.8
C 14:0	8.6 ± 1.7	7.8 ± 1.8	11.6–12.9	9.4–12.9	10.1–16.0
C 14:1	0.7 ± 0.2	1.1 ± 0.3			2.6– 3.6
C 16:0	25.4 ± 1.6	24.5 ± 3.4	15.6–16.6	26.5–35.0	28.5–32.5
C 16:1	5.6 ± 1.3	5.0 ± 1.4	0.6– 1.7	4.9– 5.9	2.5– 5.8
C 18:0	8.0 ± 2.6	8.7 ± 1.6	4.1– 4.9	9.9–14.2	10.4–11.2
C 18:1	36.5 ± 2.5	34.6 ± 5.7	22.7–30.5	27.7–37.2	30.0–30.7
C 18:2	9.0 ± 1.9	12.2 ± 3.8	24.6–28.2	7.2– 7.3	2.8– 4.3
C 18:3	1.9 ± 0.7	1.8 ± 0.8	<1.0– 1.6		1.2– 1.4

$\bar{x}$ = Mean
s = Standard deviation
N = Number of observations
A = Breast milk samples taken 4–7 days after delivery
B = Breast milk samples taken later in the lactation period
S = Semper
E = Eledon

Table 2 shows the fatty acid composition of serum from infants fed on breastmilk either from their mothers or from the milk bank. Premature babies (birth weight < 2500 g) as well as infants with a birth weight within the normal range (3000–4000 g) were studied. For the infants with a birth weight below 3000 g we preferred to give the data for the individual children, since the

Table 2. Serum fatty acid composition of infants fed on breastmilk. Fatty acid composition (% of total lipid)

Subgroup	No	Sex	Age days	Birth weight	C 14:0	C 16:0	C 16:1	C 18:0	C 18:1	C 18:2	C 18:3	C 20:3	C 20:4	No. of observations
A	745	♀	5	1650	1.6	23.4	4.6	10.0	37.6	18.2		0.8	3.1	
1500–2000 g	779	♂	5	1800	0.4	23.3	4.2	10.1	37.1	13.3		1.7	9.9	
	597	♂	19	1800	2.1	26.5	2.7	7.4	38.8	15.6		1.4	2.1	
	467	♀	1	1830	1.1	28.0	12.3	9.1	33.5	11.4			3.0	
	693	♀	5	1900	1.1	26.6	6.3	9.0	35.0	15.8		1.4	5.0	
B	741	♂	6	2050	1.7	24.9	8.5	9.5	32.1	15.4		2.1	4.9	
2000–2500 g	464	♂	4	2250	5.6	24.0	10.0	7.8	32.3	15.6			3.2	
	455	♂	6	2350	3.1	21.4	7.2	9.1	35.8	15.8			2.1	
	520	♀	6	2350	8.1	32.8	9.1	7.8	31.2	9.9				
C	468	♂	1	2600	1.3	37.4	12.0	7.6	27.9	10.6			2.1	
2500–3000 g	1187	♀	2	2750	3.3	36.2	9.5	8.9	32.2	6.4			2.3	
	797	♂	5	2900	1.5	25.5	6.8	8.9	39.5	9.9		1.6	7.9	
	1083	♀	2	2950	3.5	25.4	9.2	8.6	31.7	11.9		0.6	6.1	
D			2	Mean	5.4	33.3	7.0	9.1	31.3	8.7			4.6	10
3000–4000 g				SD	±3.4	±3.8	±2.2	±1.7	±2.7	±2.6			±1.9	
			4	Mean	4.5	30.6	6.1	7.8	33.3	8.0		4.5	5.0	3
				SD	±3.2	±4.4	±0.5	±0.9	±4.0	±3.5		±2.7	±1.1	
			5	Mean	2.8	30.0	6.2	8.2	35.1	9.4		2.2	3.1	4
				SD	±2.4	±4.0	±1.2	±0.9	±2.6	±2.4		±1.2	±0.5	
			6	Mean	4.5	27.8	6.4	9.0	33.7	13.2			4.6	6
				SD	±3.7	±2.9	±0.8	±0.9	±3.3	±2.4			±1.1	
			7		3.0	29.5	5.4	8.9	33.9	14.2			5.1	1
E	2018	♂	4	b.w. 5100	6.6	30.8	5.7	7.4	36.1	9.3	1.5	0.6	1.1	

Table 3. Serum fatty acid composition of infants fed on artificial milk products (% of total fatty acids)

No	Birth weight	Age Days	Diet	C 14:0	C 14:1	C 16:0	C 16:1	C 18:0	C 18:1	C 18:2	C 18:3	C 20:3	C 20:4
545	2650	3	breastmilk	9.4		34.8	9.0	9.1	31.1	6.7			
		6	eledon	5.8		32.0	8.7	8.0	36.6	8.7			
♂		10	eledon	4.2		26.0	7.9	6.4	32.1	14.7			8.0
665 ♀	2700	5	eledon	7.9	2.0	25.1	7.2	7.7	27.6	10.2		2.6	8.4
885 ♀	3000	6	eledon	2.6	1.8	25.6	16.7	6.6	29.2	15.0			2.6
843	2950	23	eledon	3.1	2.7	29.2	10.6	9.5	29.2	9.3		0.9	5.5
		26	semper	3.8	2.8	27.0	4.3	9.3	22.1	28.5			4.0
♀		42	semper	1.3		20.7	3.8	10.5	22.5	31.5		2.2	7.5
597	1800	19	breastmilk	2.1	2.8	26.5	2.7	7.4	38.8	15.6		1.4	2.1
		20	semper	1.1		19.6	4.3	9.1	34.2	23.3	1.7	0.5	2.7
♂		23	semper	1.9		17.0	2.8	10.5	28.2	26.8	1.7	1.4	2.9
		25	semper	3.1		16.5	2.5	8.4	30.4	31.4	1.3	0.9	3.2
576	3000	38	breastmilk + eledon	4.4		31.4	5.1	10.5	30.6	12.0			2.2
♂		41	semper	5.9		14.9	5.2	8.7	28.3	25.2	1.2	2.1	4.6
		44	semper	1.7		20.9	5.0	7.6	27.1	26.5		1.3	3.0

samples not only represent different birth weights, but also different ages post-partum and different sex. In any case, it would be difficult to group a "normal" material of premature children. In subgroups A and C, palmitoleic acid (C 16:1) is higher in samples taken 1 day post-partum than in the other samples, thus indicating that the proportion of C 16:1 of the total fatty acids in the serum decreases during the first week post-partum. The 3 samples taken 5 days post-partum in subgroup A show similar compositions and correspond to 3 of the 4 samples in subgroup B.

In the normal weight groups we find that C 14:0 and (C 16:0 + C 16:1) in most cases decrease from the 2nd day to the end of the first week, whereas C 18:1 and particularly C 18:2 increase. In spite of the wide individual variation in the linoleic acid values, the statistical evaluation of the regression line (Fig. 1) showed that the regression coefficient was significantly different from 0 ($t > t_{0.99}$).

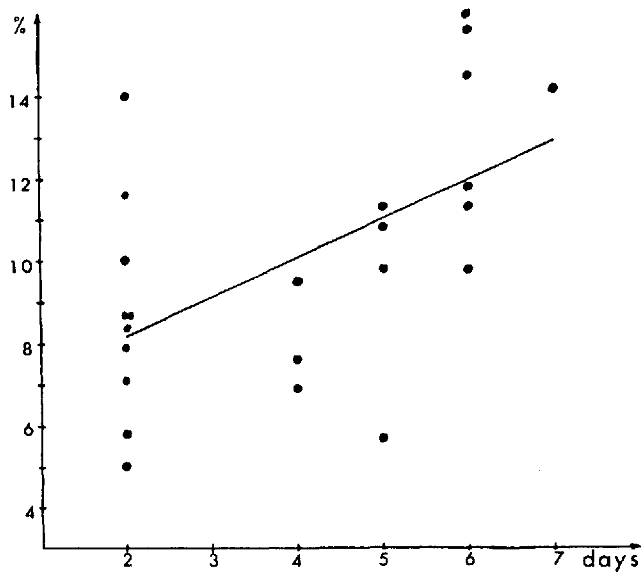

Fig. 1. The linoleic acid concentration in serum of breast-fed infants (% of total fatty acids) as a function of age

It must be concluded from Table 2 that there is no difference between the fatty acid composition of the serum from premature and full term babies, when both groups are fed on breastmilk; the fatty acid composition depends, however, on the age of the child, particularly with respect to linoleic acid.

In Table 3 the serum lipid composition of children who had received E or S is given. Initially, samples were taken from a few children before feeding and 1, 2 and 3 hours after feeding in order to establish possible differences. It was found that the fasting level and the 3 hour level were identical, whereas the 1 and 2 hour samples were identical and had a slightly higher linoleic acid content than the "fasting" samples. All results in Table 3 refer to samples taken 1–1½ hours after feeding, as these samples were considered to be most representative for the individual diet. For the majority of the children, the serum fatty acid composition was studied, after different diets had been given to the same child in order to eliminate influence of age and individual variation. Most samples were taken after the individual diet had been given for 3 days, but as seen in case no. 597 where a series of samples was taken from the same child, the effect of the diet is already seen on the first day of the new diet. As a result of S-feeding the linoleic acid content increases, eventually reaching a level corresponding to the linoleic acid concentration in maternal serum (Table 4). Another consequence of the S-feeding is that the proportion of palmitic acid is reduced, corresponding to the low palmitic acid content in the formula.

Table 4. Fatty acid composition of cord serum and maternal serum. (% of total fatty acids)

	Cord serum N = 13 $\bar{x}$ s	Maternal serum A N = 13 $\bar{x}$ s	Maternal serum B N = 15 $\bar{x}$ s
C 14:0	4.0 ± 1.5	2.3 ± 0.8	2.8 ± 1.2
C 16:0	29.5 ± 2.0	25.3 ± 2.7	25.8 ± 2.6
C 16:1	6.5 ± 1.7	5.7 ± 1.8	5.8 ± 1.3
C 18:0	9.9 ± 1.6	5.7 ± 1.0	5.8 ± 0.8
C 18:1	27.0 ± 3.4	28.5 ± 1.3	27.3 ± 2.2
C 18:2	13.5 ± 2.5	26.5 ± 3.4	26.2 ± 2.6
C 18:3		1.0 ± 0.6	0.8 ± 0.4
C 20:3	1.7 ± 1.0	1.1 ± 0.9	1.9 ± 1.1
C 20:4	8.1 ± 2.5	4.4 ± 1.5	4.7 ± 2.2

$\bar{x}$ = Mean
s = Standard deviation
N = Number of observations
A = Samples taken at delivery
B = Samples taken 4–7 days post-partum

A comparison between the values in Tables 2 and 3 shows that the fatty acid composition of children receiving E is similar to that of children receiving breastmilk; this is also illustrated by case no. 545, where the serum fatty acid composition remains unchanged when breastmilk is replaced by E.

An attempt to construct regression lines with regression coefficients $\neq 0$ for the linoleic acid concentration in a) breastmilk versus maternal serum and b) infant serum versus breastmilk showed that, according to our results, there is no significant correlation between these values. The linoleic acid content in milk and the (linoleic acid + arachidonic acid) content in infant serum did not show any correlation either.

Table 4 shows the average figures for maternal sera immediately after delivery (A) and 4–7 days later (B) plus the composition of umbilical cord serum. It was observed that in some cases arachidonic acid showed slightly higher values in the B-samples than in the A-samples, but a statistical evaluation did not show any significant difference between the two groups; the C 20:4 concentrations in group B showed, however, a wider range than the values in group A. Cord serum showed significantly lower linoleic acid and higher arachidonic acid concentrations than maternal serum. As seen from Fig. 2 and 3 cord C 18:2 as well as cord (C 18:2 + C 20:4) increased with

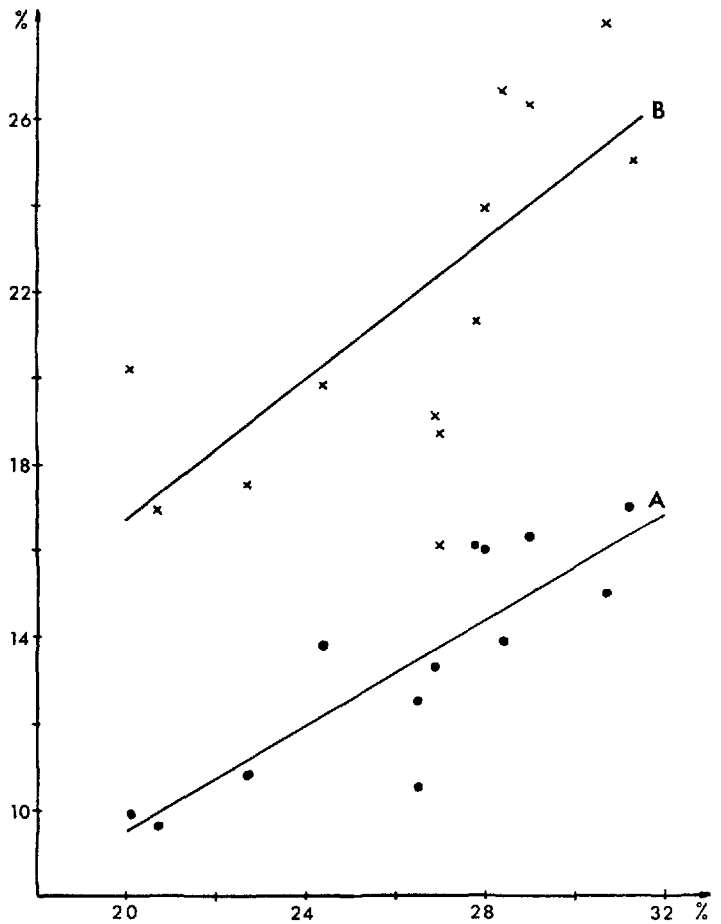

Fig. 2. A •——• Linoleic acid concentration in cord serum (% of total fatty acids) as a function of the linoleic acid concentration in maternal serum. B ×——× (Linoleic acid + arachidonic acid) in cord serum (% of total fatty acids) as a function of the linoleic acid concentration in maternal serum

increasing maternal C 18:2 and (C 18:2 + C 20:4) respectively; the regression coefficients for these two regression lines as well as the regression coefficients for the regression line for cord (C 18:2 + C 20:4) as a function of maternal C 18:2 were found to be significantly > 0 on any level.

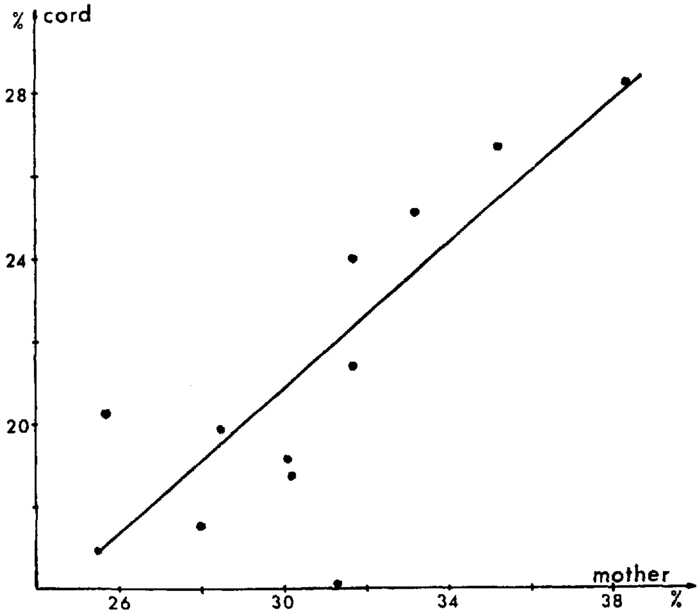

Fig. 3. The (Linoleic acid + arachidonic acid) (% of total fatty acids) in cord serum as a function of (linoleic acid + arachidonic acid) content in maternal serum

Discussion

The present data indicate that a large dietary intake of linoleic acid has a pronounced effect, since the children who had received S showed a serum linoleic acid level comparable to adult levels. On the other hand, the comparatively small differences in the content of polyunsaturated fatty acids in breastmilk did not seem to influence the PUFA content of infant serum, probably because such small variations will be obscured by other factors affecting lipid metabolism, such as hormone production, intake of carbohydrates, size of child, etc. These observations correspond in part to the data of MONTEIL et al. (16), who found that no significant differences could be demonstrated between infants fed on cow's milk powder ($^1/_2$ ecreme), breastmilk or cow's milk powder enriched with vegetable oil. They found 7.2% C 18:2 in breastmilk, which is within our range, but considerably lower than our average concentrations of 9.0% and 12.2% for groups A and B respectively. The C 18:2 content of vegetable oil/milk mixture is comparable to our data for breastmilk, thus explaining why serum of infants receiving this mixture does not differ from that of infants fed breastmilk. In our study the content of C 18:2 in S was higher than in breastmilk. These facts could explain the difference between MONTEIL's observations and ours.

Low serum level of C 18:2 has been considered to be a sign of PUFA deficiency (5, 16, 26). However, recent reports suggest an unfortunate effect of a too high dietary linoleic/linolenic acid ratio in connection with membrane formation (1, 24). Therefore, we feel that it is difficult to evaluate whether the low PUFA content really indicates a deficiency.

Another question is, of course, if the breastmilk of women living on a normal Danish diet has an optimal content of polyunsaturated fatty acids. Earlier studies have shown (11, 14) that milk content of C 18:2 increases as a result of increased intake of linoleic acid; thus on a diet containing 40–70% calories in corn oil, INSULL (11) showed an increase in milk linoleic acid.

In our study, the variations in milk lipid composition are limited by the small variations in linoleic acid consumption of women living on a Danish diet. The high standard deviation for the C 18:2 content in the milk may indicate a variation in EFA-intake, but apparently these variations were too small to influence the serum content of the infant.

The last aspect of our study to be discussed concerning the composition of the diets is the enrichment of C 18:2 in the E-product derived from dried skimmed milk as compared to whole cow's milk. We account for this finding by the higher water solubility of the unsaturated fatty acids when compared to the saturated. This point will need further investigation, but in preliminary experiments we have found a higher linoleic acid concentration (as percentage of total fatty acids) in skimmed milk than in whole cow's milk. Differences in season and the skimming techniques used in different dairies may account for the rather large variations we have so far observed in different skimmed milk samples.

A comparison between the EFA content of E and breastmilk shows that although the EFA content of E is lower than the average concentration found for breastmilk, it is still found within the breastmilk EFA-range. This could explain why the serum content of EFA was not found to be significantly lower in children receiving Eledon than in the average child receiving breastmilk.

In this connection, it should be taken into account that the children receiving E were only followed during a very limited period; if the diet had been administered over longer periods, a difference in serum linoleic acid levels between these children and those receiving breastmilk might have been seen. This has actually been shown by MENDY et al. in a study published after the completion of the present work (15).

The study of the total fatty acids of cord serum compared to maternal serum at delivery confirmed the results of SPRECHER et al. for some of the isolated lipid fractions (19, 22), in which it was found that cord serum had a higher arachidonic acid and lower linoleic acid level than the maternal serum.

When maternal and infant serum was studied during the week after delivery, we could support the finding of HANSEN et al. (7) who found that maternal serum arachidonic acid levels were higher 2–9 weeks post-partum than during pregnancy. In most children a fall in linoleic acid from birth to the second day was followed by an increase during the next week (both results statistically significant on any level). The increase in C 20:4 from delivery to the second day was even more pronounced, whereas no significant variation in this lipid could be demonstrated during the following week. The lower values of C 20:4 in the maternal serum at delivery may support ROBERTSONS suggestion (19) of a specific transport of arachidonic acid across the placenta, as well as KLEINES hypothesis (13) regarding a specific role of placenta in the metabolism of C 20:4.

We found a significant correlation between C 18:2 (child versus mother), (C 18:2 + C 20:4) (child versus mother) and (C 18:2 + C 20:4) child versus

C 18:2 (mother), and although it would be tempting to interpret the last correlation as an indication of a conversion of C 18:2 into C 20:4 by the placenta (or the foetus), the two former correlations may favour the suggestion of a specific transport mechanism for arachidonic acid (or reduced activity of the chain-elongation-desaturation system of the mother around the time of delivery).

The changes in C 20:4 concentration corresponded to the variations in the eicosatrienoic acid (C 20:3) levels. Cord C 20:3 was slightly higher than the maternal serum C 20:3 level, and whereas maternal C 20:3 increases after delivery, the C 20:3 content was less than 1% in infant serum 2 days post-partum. During the following days the highest average concentration of C 20:3 was found on the 4th day, whereafter the concentration was reduced on the 5th and was less than 1% on the 6th day post-partum. In connection with the results for C 18:2 and C 20:4 this gives rise to the following hypothesis: The child is born with a high concentration of C 20-unsaturated acids produced either by chain elongation of C 18-unsaturated acids in the placenta or resulting from an active transport through the placenta. After 2 days, the content of C 18:2 and C 20:4 is reduced and C 20:3, which could have been expected to occur as a sign of EFA-deficiency, is absent. We suggest that this may be a result of immaturity of the chain-elongation-desaturation enzyme system. The 4th and 5th day analyses still show rather low serum levels of C 18:2, but at this stage C 20:3 is present, possibly indicating an EFA-deficiency. Hereafter C 20:3 content is reduced to $< 1\%$ and by this time the C 18:2 level is significantly higher than the second day level.

Returning to the question broached in the introduction regarding the possible connection between PUFA-intake in early infancy and later development of multiple sclerosis, our study indicates that small variations in dietary intake of polyunsaturated fat do not affect the serum content of EFA.

The advantages of breastmilk compared to cow's milk as infant diet during this period has been discussed earlier by CLAUSEN (3), and our present results have confirmed that the average concentration of C 18:2 in breastmilk (Danish) is higher than that found in dried skimmed milk products made from cow's milk. On the other hand, the considerably higher concentration of linoleic acid in the lipid fraction of dried skimmed milk products compared to whole cow's milk make these products comparable to many of the breastmilk samples examined here. Addition of vegetable oil to milk products – if only one product is used as the diet of a given child – is questionable, in the authors' opinion, as long as the metabolism and function of the polyunsaturated fatty acids in the central nervous system is not fully elucidated.

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Summary

The fatty acid composition of 25 samples of breastmilk was analysed and compared with the fatty acid composition of cow's milk and two commercial milk products made from dried skimmed milk. In the breastmilk samples 7.1–16.0% of the total fatty acids consisted of linoleic acid, whereas the commercial products contained 7.1–7.2% (E) and 24.6–28.2% (S) linoleic acid (% of total fatty acids). The values found for cow's milk were 2.8–4.3%.

The fatty acid composition of breastmilk was compared with maternal and infant serum. No correlation could be demonstrated between a) maternal C 18:2 and breastmilk and b) breastmilk and infant serum. The concentration of C 18:2 in infant serum increases as a result of administration of S. The serum level of C 18:2 in infants fed on E was not different from that of children fed on breastmilk.

Umbilical cord serum showed higher arachidonic acid and eicosatrienoic acid concentration than maternal serum, but lower linoleic acid content. Both linoleic and arachidonic acid were reduced during the first two days of life. Linoleic acid increased significantly with age from the 2nd day to the end of the first week.

A significant increase in the polyunsaturated fatty acids of cord serum was found as a result of increasing levels of polyunsaturated fatty acids in maternal serum.

The biochemical problems in connection with the metabolism of the long-chained fatty acids at the time of delivery are discussed.

Zusammenfassung

Es wurde die Zusammensetzung der Fettsäuren in 25 Proben von Muttermilch bestimmt und mit der Zusammensetzung von Kuhmilch und zwei artifiziellen Milchprodukten verglichen. In der Muttermilch bestanden 7,1–16,0% der Gesamtfettsäuren aus Linolsäure, während diese 7,1–7,2% („E") bzw. 24,6–28,2% („S") der Gesamtfettsäuren der artifiziellen Milchprodukte ausmachte. 2,8–4,3% der Gesamtfettsäuren der Kuhmilch bestanden aus Linolsäure.

Die Fettsäurezusammensetzung der Muttermilch wurde mit dem Serum von Müttern und Neugeborenen verglichen. Es konnte kein Zusammenhang zwischen a) Linolsäuregehalt des Mutterserums und der Muttermilch und b) zwischen dem der Muttermilch und des Serums des Kindes erwiesen werden. Der Gehalt an Linolsäure im Serum des Kindes nimmt als Folge der Einnahme von „S" zu. Der Linolsäuregehalt des Serums von Kindern, die „E" enthalten hatten, war derselbe als der der Brustkinder.

Nabelschnurserum zeigte einen höheren Gehalt an Arachidonsäure und Eicosatriensäure, aber weniger Linolsäure als das Serum der Mutter. Der Gehalt sowohl an Linolsäure wie Arachidonsäure wurde in den ersten zwei Lebenstagen verringert. Vom 2. bis zum 7. Tag an konnte eine signifikante Steigerung an Linolsäure erwiesen werden.

Eine signifikante Steigerung an mehrfach ungesättigten Fettsäuren im Nabelschnurserum begleitete steigende Mengen der mehrfach ungesättigten Fettsäuren im Serum der Mutter.

Die biochemischen Fragen im Zusammenhang mit der Umsetzung der langkettigen Fettsäuren zur Zeit der Geburt werden diskutiert.

References

1. Bernsohn, J. and L. M. Stephanides, Nature **215**, 821 (1967). — 2. Biochemisches Taschenbuch II (ed. H. M. Rauen), p. 895 (Berlin-Heidelberg-New York 1964). — 3. Clausen, J. and J. Møller, Acta Neurol. Scand. **45**, 375 (1967). — 4. Davison, A. N. and J. Dobbing, Brit. Med. Bull. **22**, 40 (1966). — 5. Degrelle-Cheymol, C. and L. Binet, C. R. Acad. Sci. **259**, 4868 (1964). — 6. Folch, J., M. Lees, and G. H. Sloane-Stanley, J. Biol. Chem. **226**, 497 (1957). — 7. Hansen, A. E., H. F. Wiese, D. J. D. Adam, A. N. Boelsche, M. E. Haggard, M. D. Davis, W. T. Newsom, and L. Pesut, Amer. J. Clin. Nutr. **15**, 11 (1964). — 8. Holman, R. T., Fed. Proc. **23**, 1062 (1964). — 9. Holman, R. T., W. O. Caster, and H. F. Wiese, Amer. J. Clin. Nutr. **14**, 70 (1964). — 10. Hølmer, G., G. Kristensen, E. Sondergaard und H. Dam, Z. Ernährungswiss. **2**. 223 (1962). — 11. Insull, W., J. Hirsch, A. T. James, and E. H. Ahrens, J. Clin. In-

vest. **38**, 443 (1959). — 12. JAMES, A. T., J. Chromatog. **2**, 552 (1959). — 13. KLEINE, U., Clin. Chim. Acta **17**, 479 (1967). — 14. KRAMER, M., K. SZÖKE, K. LINDNER, and R. TARJAN, Nutr. Dieta **7**, 71 (1965). — 15. MENDY, F., J. HIRTZ, R. BERRET, B. RIO, and A. ROSSIER, Ann. Nutr. Alim. **22**, 267 (1968). — 16. MONTEIL, H., F. KLEIN, R. RUFF, J. KREMBEL et J.-M. LEVY, Ann. de Pediatrie **43**, 23 (1967). — 17. O'BRIEN, J. S. and E. L. SAMPSON, J. Lipid Res. **6**, 545 (1965). — 18. PIKAAR, N. A. and M. D. FERNANDES, Amer. J. Clin. Nutr. **19**, 194 (1966). — 19. ROBERTSON, A., H. SPRECHER, and J. WILCOX, Nature **217**, 378 (1968). — 20. SINCLAIR, H. M., Lancet **1956/I**, 381. — 21. SPIEGEL, M. R., Theory and Problems of Statistics (New York 1961). — 22. SPRECHER, H. and A. ROBERTSON, J. Lab. Clin. Med. **70**, 489 (1967). — 23. SWANK, R. L., A Biochemical Approach to Multiple Sclerosis (Springfield, U.S.A. 1961). — 24. WALKER, B. L., Lipids **2**, 497 (1967). — 25. WOODRUFF, C. W., M. C. BAILEY, J. T. DAVIS, N. ROGERS, and J. G. CONIGLIO, Amer. J. Clin. Nutr. **14**, 83 (1964). — 26. ZÖLLNER, N., G. WOLFRAM, W. LONDON und K. KIRSCH, Klin. Wschr. **44**, 380 (1966).

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Über die ernährungsphysiologischen Eigenschaften von Fisch-Frittierfetten

1. Mitteilung: Einfluß des Frittierens auf chemische Zusammensetzung und Futter-Efficiency

Von K. LANG, E. H. VON JAN und J. HENSCHEL

Mit 3 Abbildungen und 10 Tabellen

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Die Frage nach den ernährungsphysiologischen Eigenschaften von den an der Luft erhitzten Fetten hat in der neuen Zeit eine zunehmende Beachtung gefunden. Zahlreiche Untersucher haben sich schon mit diesen Fragen experimentell beschäftigt. Es unterliegt keinem Zweifel, daß man durch eine starke thermische Behandlung, d. h. beim Erhitzen für längere Zeit auf hohe Temperaturen, in Fetten erhebliche chemische Veränderungen erzeugen kann, die zu einer Abnahme der Nährwerte, ja zum Auftreten mehr oder minder stark toxischer Substanzen führen kann, so daß man im Tierversuch bei der Verfütterung solcher Fette nachteilige Folgen, angefangen von Wachstumsverzögerungen bis zu einer hohen Letalitätsrate der Tiere, zu sehen bekommt. Dies ist insbesondere dann der Fall, wenn die Durchmischung der heißen Fette mit dem Luftsauerstoff intensiv ist, etwa beim Durchspülen mit Luft („geblasene" Fette), und wenn Fette mit einem hohen Gehalt an Polyensäuren gewählt werden. Von LANG und Mitarb. wurden erstmalig systematische